

TABLE 1

Potential Diffusive Transport Modifier	Molecular Weight	Concentration Wt. % (Mass additive/mass water)	$\eta_{water}/\eta_{solution}$	Electrical Conductivity Reduction Factor for KCl/Modifier Solutions vs. KCl/Distilled Water Solutions (moles of chloride ion per unit mass of solution) 0.1 mol/kg
Xanthum Gum	≈1,000,000	0.4	0.43	1.00
Cellulose Ether	≈100,00	0.29	0.30	0.98
Polyvinyl alcohol	≈10,000	2	0.58	0.98
Polyoxyalkylene alkyl ether	≈400-1,000	11	0.67	0.67
Polyoxyalkylene alkyl ether	≈400-1,000	25	0.39	0.47
Polyethylene Glycol 600	≈600	18	0.52	0.67
Polyethylene Glycol 400	≈400	25	0.44	0.56
Polypropylene Glycol P400	≈400	11	0.66	0.75
DOW PT 250 Polyglycol	≈250	11	0.70	0.77
Dipropylene glycol/Propanol, [2-,1-dimethylethoxy)methylethoxy] Glycerol	≈134/90	11	0.72	0.76
	≈92.1	43	0.48	0.49

**[0035]** As shown in Table 1, a general trend is that the larger the molecular mass of the modifier, the lower the concentration required to increase the viscosity of distilled water. If increasing the bulk viscosity were an objective of the present invention, large molecules such as cellulose ethers, xanthum gum, and polyvinyl alcohol would clearly provide the most cost efficient means. However, an objective of aspects of the present invention is to decrease the diffusivity rate of deleterious species in a concrete pore solution. Diffusivity is estimated by conductivity in the initial screening since a decrease in conductivity may provide a decrease in ion mobility.

**[0036]** Table 1 shows that some of the materials initially screened for application as a diffusive transport modifier are effective in reducing the solution conductivities, while others have little or almost no measurable effect on conductivity. The larger molecules such as cellulose ether, xanthum gum, and polyvinyl alcohol were shown to have almost no influence on conductivity within the solutions despite their measurable effects on bulk viscosity. Conversely, the smaller nano-sized molecules having a molecular weight less than 1,000 g/mol were shown to be effective in reducing conductivity. Therefore, aspects of the present invention have a diffusive modifier with a molecular weight of at most 1,000 g/mol.

#### Example 2

**[0037]** Based on the results of Example 1, polyoxyalkylene alkyl ether was selected for use as diffusive transport modifier in a series of mortars with a water-to-cement ratio (w/c) of 0.4. The diffusive transport modifier was added at a concentration of about 10% (of total solution mass), which provided a viscosity increase of 1.5× in distilled water as shown in Table 1. Three methods were employed for delivering the diffusive transport modifier into the mortars, and are described schematically in Table 2 for each method and its corresponding control. The first method comprised the conventional method of making concrete where the aggregate(s), water, cementing agent(s), and diffusive transport modifier(s) are all mixed to form the wet concrete mixture. The second

method included a topical curing solution that contained the diffusive transport modifier for delivery into the concrete. The third method used porous fine lightweight aggregates (LWA) saturated with a concentrated solution of the diffusive transport modifier prior to incorporation into the wet concrete mixture.

TABLE 2

Method	Organic Water Soluble Diffusive Transport Modifier Application		
	Wet Concrete Mixture	Surface Application	Admixture-Saturated Porous Aggregate
1/Control	YES/NO	NO	NO
2/Control	YES/NO	YES/YES	NO
3/Control	NO	NO	YES/NO

**[0038]** Wet mixtures were prepared by each method and a control sample was also prepared by each method for comparison. The wet mixtures were placed into cylindrical molds having a 50 mm diameter and a 100 mm length (about 2"×4") and allowed to cure for 1 day, forming concrete cylinders. Concrete cylinders having polyoxyalkylene alkyl ether prepared by the first method and concrete cylinders prepared as a control having no polyoxyalkylene alkyl ether, were further cured for a total of 7 days and 28 days.

**[0039]** Concrete cylinders were prepared by the second method, with and without polyoxyalkylene alkyl ether in the wet mixture. After curing for one day, the cylinders were further cured in polyoxyalkylene alkyl ether solutions for a total cure time of 7 days and 28 days. The second method and its control cylinders were both cured in a solution of 1.1% NaOH/KOH/Ca(OH)<sub>2</sub> and 11% polyoxyalkylene alkyl ether.

**[0040]** The concrete cylinders prepared by the third method were cured in sealed double plastic bags for a total cure time of 7 and 28 days. These concrete cylinders were prepared by pre-wetting the dry lightweight aggregates with a 50% solution of polyoxyalkylene alkyl ether in water prior to adding to the wet mixture that was placed into the mold. The control